VOLUME XLII • NUMBERS 1-2

December 1959

THE Biologist

ΑΛΗΘΕΙΑ ΕΚ ΤΗΣ ΓΗΣ

A
arterly Journal
Promoting
search Interest
in the
logical Sciences

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THE Biologist

The Biologist is the official publication of the Phi Sigma Society, a nonprofit educational organization devoted to the promotion of research interest in the biological sciences, founded at Ohio State University 17 March 1915. Phi Sigma is a member of the Association of College Honor Societies and the American Institute of Biological Sciences and an Associate Member of the American Association for the Advancement of Science.

The Biologist is issued as a stimulus to the fellowship in science for which Phi Sigma stands and as a medium of exchange between Chapters. The Council Officers assume no responsibility as to the opinions of the contributors to this publication.

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The Cultivation of "The Proud Mind of Man"[1]

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IN THIS age of mass-democracy, one of the most vital and pressing problems confronting society is that of finding and developing genuine leaders. Obviously, the answer to the problem must include both the means of finding potential leaders and a philosophy to govern the guidance of their development. This, in the last analysis, means education.

But what do we mean by education? And how may it be made most effectively to serve the purposes of life in a democracy?

In the first place, let me say quite plainly that I most emphatically do not consider specialized training of an individual in some vocation, such as engineering, medicine, or the legal profession as education. Further, I do not consider education as primarily a "training" for anything, although a training of the mind is a necessary and an almost inevitable by-product of education. I do not believe, either, that the primary purpose of education is the social adjustment of the individual to the group. Nor do I accept the conclusion of Paul Woodring that education is the preparation of the individual to "make wise decisions."

What I do believe education is, is the introducing of the individual to so many and such rich experiences that he may achieve the good life, and that the good life may mean for him the best, the richest, the fullest, the deepest,—in other words, the most enjoyable—and, incidentally, the most useful life that, for him, with his peculiar, individual attributes, physical, intellectual, emotional, and creative, may be possible. All the technological training in the world cannot cultivate these things in him. The best that technological training can do is to produce a lot of human "trained seals."

In the second place, let it be clearly recognized that men are not equal. Science has abundantly proven, and the classroom experience of every school-teacher in the land has amply demonstrated, that every individual is different from every other in the world (with the possible exception, perhaps, of identical twins), especially in intellectual endowment.

If we apply this principle to our modern situation, it seems to follow that our educational system should recognize the scientifically demonstrated fact that children are not equal, and provide for every individual the maximum of education that the individual can assimilate. This would mean that the superior student, the so-called "fast learner" would be spotted early in the course of his schooling and would be given every opportunity to proceed as rapidly and as deeply as he might be capable of doing.

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[1] Reprinted from The Newsletter of the Inter-University Committee on the Superior Student. Vol. 2, No. 3, April 1959.

Most of our educational outlook and practice in this country, however, revolves about the "norm," the "average,"—yes, the mediocre. Much of what we do in the schools is based upon the I.Q. of 100; the students with I.Q.'s above 100 are neglected. Even where there is a curriculum for the superior student, the program laid out for him is generally far less rich and challenging, far less calculated to make his life genuinely the good life, as I have described it, than it might be.

What I propose is that we re-cast our attitudes and practices in education in such a way as consciously to find our exceptional, gifted individuals, our potential intellectual leaders, and then give them the richest educational experience it is possible for them to have.

There are, of course, many who would honestly oppose any such scheme of education on the ground that it is undemocratic. It appears to favor some and discriminate against others. Let all, these opponents say, have the same (that is to say, "equal") education. This, and only this, is democratic equality. Furthermore, they say, if you educate individuals along different, individualistic lines, you are likely to raise up a lot of dissenters, of critics of the status quo. But this is dangerous; it even leads to "subversion;" it might even lead, logically and eventually, to an end of democracy itself.

On the other hand, there are many who oppose the kind of education I am suggesting here on the ground that education must be "education for something," by which they mean engineering, medicine, and so on. Anything else is a waste of time.

It is these moods that dominate much, if not most, of our thinking about public education in this country today. These moods, too, are just one more set of expressions of the mass mind.

What we are concerned about here, in the first place, are the dangers to democracy itself that lie inherent in such moods. For the sort of "equal" education suggested by these opponents is obviously suicidal, so far as leadership is concerned. More than anything else, democracy needs enlightened, really educated leaders. But the sort of education envisaged by the current moods of the mass democracy would not cultivate leaders; on the contrary, it would discourage and impede their development; it would

—and does—have a tendency toward a suppression of exceptional talents within the bounds of mediocrity. And it goes without saying that mediocrity can never furnish a truly enlightened leadership.

Nor will purely technological training produce the qualities of intellectual and cultural enlightenment that are essential to the true leader. For these qualities reside in a part of human nature that technological concerns almost never touch.

Apart from the need of society for leadership, however, is the duty of a truly democratic society to provide for every individual the means of achieving the "good life." This, I repeat, means the broadest possible range of experience: the rich experience of knowing for its own sake; the plumbing of the depths of understanding of life and its most profound meanings and values; and opening of the broadest horizons of beauty, with a sharpening of one's critical appreciation of it and articulateness in communication of one's feelings; the cultivation of the individual's creative talents, whether in literature, in art, in music, in philosophy, or in science, and a sense of the principles that govern the most tolerant and generous relationships between individuals and peoples. Above all, it means the intellectual and moral courage to think and speak freely in all matters of concern to the individual or to society. It is my profound conviction that the cultivation of every individual, in this sense, to the utmost limits of his individual capacity, is the true meaning of democracy in education.

The implication of what I am saying, in all honesty of conviction, is, that democratic education, in this sense is bound to bring into existence a sort of intellectual elite. It is a "natural" elite, to use Jefferson's words, which would include both the most cultivated persons and the most enlightened leaders in society. There can be, of course, no sharp line between this so-called elite and the other members of society. Rather, ideally speaking, the result of such a system of education would be a society of fully educated individuals, in which there would be an imperceptible shading from the level of those of least capacity to that of those of the greatest. And there would always be the freedom of movement that would make it possible for persons of ability to move upward to the top.

But there would be a top. It's no use to say all men are equal and then try to force them to be equal in cultural attainments when nature has actually made them unequal. Why try to force men to be all alike in the name of a pernicious dead-level of mediocrity?

Actually, a certain amount of this educational selection is taking place now. Generally speaking, it is the superior students who get through high school and go on to college; it is the superior student who finishes college and gets elected to an honorary scholarly society. But our perverted obsession with the pragmatic, the vocational, and the technological aspects of our so-called "education" has led to the production of an elite of wealth, of technology, of science, and of the professions—including schoolteachers—who are not truly educated, nor "enlightened," in the sense of the word used in this discussion, and who are leaders in every way except truly intellectual and cultural ways.

This means that the genuinely educated, the "civilized" individual is a rarity among us. Worse still, it means that while we are building hydrogen bombs and moon-satellites, we have practically forgotten the things without which the value of the scientific or technological achievement is nil. I mean the joy of living itself—the enjoyment of knowledge, the deepening of the human understanding, the appreciation of beauty, the development of generous, humane, tolerant and cultivated relationships among men in society and among the different peoples of the world. These are the qualities that make for true civilization. They are enduring qualities, the growing, developing qualities that make life more and more worth living; and it is their steady and constant unfolding that is the key to any valid distinction between civilization and savagery, between men and animals.

If one will reflect upon the achievements of human civilization in the course of its long history, in the Mediterranean area, in India, in China and Japan, or in the Atlantic civilization, he will be struck by the fact that almost without exception the great monuments of human progress—the philosophies of the ancient Greeks and Chinese, the architectural wonders of India or the Feudal West, the works of Shakespeare, the music of Beethoven or Brahms, or the engineering and scientific triumphs of the twentieth century—all have been the creations of the human intelligence at work. It is upon the cultivation of this intelligence in its integral relationship with the emotions—what Kozantzakis, in his modern sequel to Homer's Odyssey, calls "the proud mind of man"—that the future peace, progress, and happiness of mankind depends. But the proud mind—or spirit—of man is not merely technological, nor scientific alone. We must remember that man does not live by bread—nor rockets—alone. Those things, important as they may be, are on the periphery of human life. The things that count most, that have always counted most, and that always will, are the qualities that make human life itself, after all, worth while. I greatly fear that we may today stand in real danger of losing those qualities in our interest in winning the race of the missiles.

The Reevaluation of Teaching Biological Sciences and the University of the Philippines

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THE LAST few years have seen a reevaluation of teaching methods in the various curricula of all schools from the kindergarten to colleges and universities. After the launching of the first sputnik, the government and the public joined forces towards achieving a common goal. In the Philippines, the biological sciences have been undergoing revision in the method of their offering under special study groups. It is hoped that the various study groups use the experience of members who have had actual laboratory experience with the materials that it is proposed to use to effect the reorganization. If the members consist of teachers who got their information only by reading references and textbooks on biological subjects, they are not as competent as they should be to formulate changes in the present curricula. Either they put in changes too impractical to follow or their suggestions will lead to confusion because they have not actually tried out the operation of what they have read about. The successful operation of the teaching of biological sciences needs teachers who have had experience in setting up experiments and in the actual performances of the proposed modifications.

It might be wise to restore teaching about plant and animal life to the higher elementary grades as a part of the reevaluation program. The boys and girls in these grades will thus be introduced early into an appreciation of their immediate environment. There is no better time to develop an interest of the materials presented in beginning courses in the biological sciences than the latter years of elementary education, when the pupils are just in their adolescent period. The teaching is calculated to be more effective at that time than when taught later on in the secondary schools.

However, it is most probably in the secondary schools where the greatest effect of reevaluation can take place as a result of systematic changes in the biological curriculum. The pupils at this age have the greatest desire to learn more because of the experiences they have had in the elementary grades. Since the greater percentage of the high school graduates never go to college, it must be during the secondary education period that general biological principles must be taught. But, at this juncture, the question of whether or not all biological subjects can be taught effectively arises. I suggest that only the most important biological principles should be emphasized. There is obviously insufficient time to cover with adequate explanation or demonstration every fundamental principle. Observations show that pupils retain very little from courses taught by less competent and less inspiring teachers. On the other hand, the teacher, no matter how good he is, cannot cover all subject matters. Therefore, only the principles needed by every educated person should receive emphasis. Thus the teachers must be of the highest competence to teach effectively the fundamentals which the pupils need in modern society. Nowadays the general education for young persons is a sound demand of society. It follows that the pupils also need time to acquire knowledge outside the biological field. Most individuals of high school age never go on to colleges and universities, but have just as much need of a general education as do those who do go on. The educated individual should be able to think clearly, and critically, and be able to judge the competence or incompetence of his fellow beings.

In the University of the Philippines, the freshmen are given specific biological subjects, Botany and Zoology, during the preparatory medical course. Other students must take general biology. Presently, a restudy of the course offering has been made by a competent committee. The syllabus method is used for the first time. This is the main problem confronting the faculty in the biological departments of the College of Liberal Arts. It is not easy to implement such a new approach because the University has very incomplete information about the methods of biological instruction in the secondary schools. The freshmen of the University have just graduated from different high schools where the standards of biology teaching varies greatly. This major problem has arisen because of the absence of the proper relationship between the University and the secondary schools.

But there are suggestions which are very timely for the successful operation of the present reevaluation of biological teaching at the collegiate level. The chapters of the syllabus should be written by competent faculty members who have broad scientific experience and a progressive academic preparation. It would be advantageous if the selection of personnel were based to a greater extent upon proficiency in both teaching and productive research.

The instructor should devise ways and means to understand the students; the students should also have the opportunity to understand the instruction. The faculty members handling the course should not mind sitting together regularly to consult with each other concerning the results of their teaching. Audiovisual aids, such as film, reliable demonstrations, experiments, and other key materials illustrating the biological principles presented in the syllabus should be included. Considerable time, perhaps more than two to three years will be necessary to effect the desired adjustments. Display showcases must be prepared for the various demonstrations for the benefit of both the students taking the courses and the rest of the University population. The general public may likewise like to look at some of this material.

Teaching competence is revealed when the students are happy and they have the ambition to continue their education after taking the course. The able high school students who seek higher learning in the University of the Philippines are inspired and stimulated towards greater intellectual achievements. In view of this, it may be necessary to extend the idea of reevaluation by revising also the present system of too much concentration on education for all, which includes the slow learners and the handicapped. The superior students are oftentimes delayed because they sit idle in the class while waiting for their slower classmates to finish an assignment. There should be a way to accelerate the bright and better prepared students. The advent of the space age requires that the old system of practically giving the same work to superior and non-superior students be changed. For the welfare of society and of the country, including the welfare of the slow learners and the handicapped themselves, this part of reevaluation should take place immediately through the rapid promotion of superior students.

The Alpha Chi Chapter, Phi Sigma Society, has a responsibility to perform, both in the promotion of interest in research in the biological sciences and in the production of scholars in the University of the Philippines. The reevaluation program, when properly implemented, is an important element in such a program.

The author of this paper is Council Representative, Alpha Chi Chapter of Phi Sigma.

Pressures of Population—An Ecologist's Point of View[1]

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It is the business of the ecologist to study the mutual relationship of living things and their environments. In doing so he encounters certain peculiar phenomena otherwise neglected by science. While it should have been clear from the days of Darwin that neither life nor environment can be understood apart from the other, ecology is still fairly new, and has been largely concerned with the affairs of plants and animals. Its application to mankind has lagged for a number of reasons. For example, students of mankind are afraid of being labeled "environmentalists" and are sensitive about applying biological "analogies" to their own species, even though intelligent analogy properly used is a powerful tool of science.

Yet as we scan the past or appraise the present scene nothing is more evident than the effect of environment on human beings and their profound effect upon it. Man is quite capable of producing changes that lessen the capacity of his surroundings to sustain him. He is an active physical object, occupying space and subject to the sheer physical stress of other dynamic objects. He is a biological entity, with certain minimal requirements for survival and development. He is also a sentient being with vast capacity for learned behavior, whose actions and values become patterned into forms we call cultures. Indeed, it is through such patterned cultures rather than his spontaneous, instinctive behavior alone that he is largely related to his environment.

The planet Earth upon which he lives (and from which he shows some symptoms of wishing to escape) is at least 3000 times as old as his species. He has come into existence and survived thus far by virtue of developments that took place during long prehuman time. He is the beneficiary of such changes as the evolution of other forms of plant and animal life suited to his needs, and the concentration of mineral ores and fossil fuels.

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[1] Reprinted with permission from What's New, No. 212, 1959, published by the Abbott Laboratories.

But he also survives by virture of orderly and dynamic processes whereby energy and materials are transformed and deployed. Radiant energy from the sun is impounded in organic forms instead of being immediately dissipated. The earth's surface is stabilized and soils developed by virtue of living cover. Water drawn from the seas and dropped upon the land is retarded by vegetation and stored above and below the surface, thus becoming available to sustain terrestrial life. Living communities of plants and animals tend to become systems adjusted within and without to the efficient use and reuse of energy and materials.

Man's Relation to the Limits of His Environment

Some 10,000 years ago—1/300,000th of the earth time—man began to domesticate food plants, thereby gaining leisure for improving his lot as well as the means of establishing sedentary life. Where the processes of nature had combined to furnish favorable conditions, such as fertile soil and sufficient moisture, the primitive agricultural communities, well-nourished, developed into centers of population, invention and power. Such were the plains of Rome, the valleys of the Tigris, Euphrates and Nile, the Basin of Mexico, and Yucatan peninsula.

But each such center grew by what it fed upon and devoured that which had made it possible. The Roman plain became the Pontine Marshes, the valley of the Tigris and Euphrates a battleground whose irrigation works, already choking with silt, were finally destroyed by invaders, the Nile valley a swarm of humanity living in mass poverty. The Basin of Mexico, having nourished the Nahua so well that they overran the rest of Mexico, succumbed at length to conquerors who felled its hillside forests and drained the lakes which were its lifeblood. Today its millions live in extremes of wealth and misery amidst a group of dry and dusty basins. Eastward the majestic ruins of Yucatan and Guatemala have been overrun by jungle.

To the ecologist, these are not mere incidents, attributable to the unholy ambition or incompetent guidance of powerful individuals. They fit, instead, a pattern familiar to all who have studied living organisms. The key to this pattern lies in this principle: no form of life can continue to multiply indefinitely without eventually coming to terms with the limitations of its environment. To this principle there is no exception recorded in biological literature. Its operation can be observed on every hand. The yeast in a cider-barrel or pan of dough ceases to multiply when sugar is exhausted. The trees of a mature forest arrive at a favorable spacing by elimination of the less vigorous, while each forest type tends to be limited to those conditions of soil, moisture, light and other factors most favorable to it and least favorable to its competitors. The cycles of abundance and scarcity of game animals, familiar to every sportsman, fluctuate about an average that represents the capacity of a habitat. Every wise gardner knows better than to crowd his luck by crowding his plants too closely. Even the most aggressive of organisms, such as weeds, rodents and noxious insects, do not increase and spread indefinitely.

Man–His Own Worst Rival

While many factors operate to stabilize these populations, it is an ecological observation that the most serious potential competitor of any species is one whose requirements are most like its own—one that occupies the same niche and performs the same role—in other words, its own kind. Thus man can be man's own worst rival. Unless other controls operate, competition within the species must do so.

On the whole, we tend to be fairly practical about such matters when they involve other forms of life than our own. There are, of course, exceptions due to custom or social values that may once have been better justified than they now seem to be. Witness the useless excess of ponies on certain Indian reservations in the Southwest, the scrawny cattle in parts of the Orient and the starving dogs of old Constantinople. But the most notable, serious and widespread exception has to do with the human population itself.

The facts are fairly well known. From the end of the Roman Empire until the sixteenth century, the numbers of our own species remained fairly constant at an estimated half billion, fluctuating of course with war, disease, famine and favorable conditions. In the next three centuries they seem to have doubled, then doubled once more in the nineteenth century. Since 1900, thanks to improved health measures, the acceleration continues along a course whose steepening curve would, if any other form of life were being studied, clearly indicate that it must level off or run into disaster.

One can be certain that graphs are taken very seriously in problems of engineering and industrial design. When measurements suggest that a reasonable—generally conservative—factor of safety may be exceeded the red flag goes up. Structures, machines and processes are today devised in an atmosphere of respect for the laws that govern the behavior of energy and matter. We are less consistent when it comes to the laws that govern the earth and its inhabitants, picking and choosing. Ready to use geological principles in finding minerals and to respect biological laws in medicine and agriculture, we seem reluctant to apply their lessons to our own past, present and future. Surely a curious ambivalence this, in a scientific age!

So far as the average citizen is concerned, his attitude, or rather his uncertainty and confusion, are quite pardonable. Endowed with the most insistent of reproductive urges—an urge whose consequences are far less immediate and for more complex than those that may result from mixing a solution or throwing a switch—he is influenced by inertia, custom, tradition and the voices of his time. His ethical leaders, despite their common belief in the dignity and worth of human life, do not always see eye to eye. He is also compelled to listen to those who have no vision, or what is worse, no motive beyond their own advantage. He is, thanks to modern technology, part of a world that has come to believe in effortless plenty as the normal order of nature, to be enjoyed by those who have it and secured at all costs by those who lack it. Self-pity is condoned as envy never was.

More and more he seems inclined to rely upon science, if not for any ultimate assurance of the kind called spiritual, at least to protect him from the physical consequences of his present course. The prevailing forecast, soberly stated in a significant, highly literate and sensible article,[2] outlines the purely mechanical side of our glorious future as including two days of work per week, space travel, world tours for school children, flowering deserts and domesticated jungles. True, the writer proceeds to emphasize more creative possibilities and perhaps the preceding prophecy was quoted with tongue in cheek. I hope so, for laying aside its failure to charm and challenge me, I have seen enough of deserts and jungles, of human physiology and human nature to make me doubt the merit, if not the possibility, of such a dream.

Having witnessed the development of automobile, airplane, radio, and television, mass production and atomic power, I would consider it folly to underestimate man's capacity to discover new principles and apply them. It would be an even greater folly, however, to overlook the basis of all scientific advance and to assume that, because something becomes technically possible, any and all of its applications are therefore justified and that consequences can be left to work themselves out. Such an assumption renders impotent the primary function of science, which is to afford mankind an understanding of and perspective on the universe of which he is a part. It disregards the usefulness of history and the necessity for moral choice. In particular it casts aside the rules of experience of the ecologist who has learned to see all living as a process in which trends and rates have been a key to the present and should in a responsible society be a guide to the future.

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[2] Jerome Ellison, "Are We Making a Playground Out of College?" Saturday Evening Post, 231: 19, March 7, 1959.

The "New Superstition" ... and Feeding × 10

There is abroad today what might be called the new superstition. Huxley has called it "the airy assumption that 'science' will surely find a way out." Coupled with it, as Margaret Mead has discovered, is a curious mistrust of the scientist himself as something scarcely normal and human. For all of its sophistication, this is not far from the attitude of primitives toward the shaman or medicine man—an individual essential to the group, but to be feared as the devil hates Holy Water or a timid child dreads the dark.

With a few exceptions, responsible scientists themselves are properly cautious in their appraisal of the future. It is encouraging to note that those whose astounding brilliance now catches the eye—the physicists—have taken a lead in expressing moral concern over the use to which their discoveries may be put. As often happens, misunderstanding has its source in arrogance of disciples rather than the humility of masters.

Yet because the growth of human numbers seems to have so desperate and all but hopeless a momentum, much high competence has been addressed to the problem of how great a population the earth can possibly sustain. This, even though it may serve to nourish a dangerous optimism, is nevertheless a legitimate and essential form of inquiry. Such estimates range from five to ten times the present count of mankind as being technically feedable. Needless to say, this assumes a far more efficient use of available energy and materials than at present, far greater social coordination than is now in sight, and almost complete dependence upon an elaborate chain of technological process.

In effect it calls upon the microbiological laboratory rather than the world of nature for its model. Everything must be sacrificed to the end of maintaining pure cultures at a standard of maximum yield. This statement is no mere exercise in rhetoric. Visit a modern orchard or the irrigated valley of the Platte River. The basic technique of modern agriculture, now threatening the traditional family farm with extinction, is plain to see. It involves sterilization and reinoculation with those organisms considered to be essential, so far as this is possible. So efficient—for the time being at least—has this become that in New York State one may see vast heaps of apples, like the coal reserves of a power plant, piled outdoors to await processing. In Nebraska and Iowa the clusters of aluminum structures for storing surplus grain increase in size each year. The individual farmer, who now feeds three or four times as many mouths as did his grandfather, cannot afford to produce his own sustenance, but must purchase most of it, along with his increasing costs for power, plant nutrients and feed. To do this he requires subsidy from public funds. Yet if all the present surplus from the United States could be distributed to the hungry of other lands, it would provide no more than the equivalent of a cupful of cereal a fortnight for each.

Clearly enough, the business of feeding an ever-expanding population will not be simple. A meager grain of comfort lies in the vague admission by even the most optimistic that conditions must eventually stabilize, however crowded the earth may then be. But somehow this smacks too much of a willingness to take on a secondary responsibility while neglecting the basic one. It substitutes the problem of what can be for the more pertinent question of what ought to be.

Whether we consult the physics of dynamic particles, the observations of laboratory and field, or the lessons of human history, certain conclusions are plain. Stress and sacrifice of freedom increase with crowding. They also increase when energy is added to the system, as is happening to human society with its extravagant use of fossil fuels and internal combustion engines. One evidence of this lies in an annual highway death toll exceeding our nation's battle fatalities in World War I. Another lies in the tragic increase of personality disturbances, while present international tensions doubtless owe as much to terrestrial crowding in a technological era as to that perennial scapegoat, the innate perversity of human nature.

A Balanced View of an Enduring Human Society

Yet another conclusion can be drawn from physical and biological as well as historical phenomena. For physical systems this principle is expressed in those rules of experience known as the laws of thermodynamics. Processes tend to move toward conditions of minimum stress. If a continuing supply of energy is available and so organized as to maintain the set-up in working order, the system continues to operate. Otherwise it disintegrates and is replaced.

For biological systems the principle is exemplified by organization and succession toward dynamic stability and efficient use of energy and materials. It is the fashion today to criticize this concept because its operation is often obscured by evolutionary change and environmental vicissitudes, but this does not invalidate the results of long observation.

So far as human society is concerned, the principle has never been more clearly and explicitly stated than by John Stuart Mill in his magnificent brief chapter called "The Stationary State." This chapter, too long overlooked by those who call themselves conservationists, is virtually their intellectual charter. It makes clear that any enduring human society must somehow develop into a condition of equilibrium, within and without. Naturally, Mill used the word "state" in its political sense, but his title today could be translated into terms of universal scientific discourse by changing it to "The Open Steady State," using the final word as the physical scientists employ it to represent condition.

Such a condition is open in the sense that it continues to receive energy, basically from the sun. It is steady in the sense that this energy, instead of being completely and irresponsibly exploited, serves to maintain a working order as one of its functions. This need not, for human society, imply stagnation. So long as the environment continues to challenge us with possibilities for new understanding, work and enjoyment, and so long as the creative impulse in man survives and the individual realizes that time does not end with his own span, an ordered society can be the background for great achievement and continuing interest.

It is well to recall, in our kaleidoscopic present, that here and there, for long periods, societies have achieved, in some measure, this dynamic stability. The fact that they have been very different from our own should not blind us to their merits. China long exemplified such a condition. So did the continent of Africa, which, in the judgment of those who know it, maintained a beautiful equilibrium between man and environment until overwhelmed by more powerful cultures.

I have just returned from a brief glimpse of the highland Indians of Guatemala. These sturdy little people still maintain, as they have for centuries, an almost perfect balance between the natural forest cover and their self-sustaining agriculture. Their practice rivals the most advanced type of scientific block-cutting now practiced in the Pacific Northwest. When a forest is cleared, a few fine trees are preserved for seed and future harvest. Branches are removed to a considerable height to avoid shading of the crops and these branches are used for fuel. Adjacent forest is left standing; and when the field is ready for rest after a few years, it promptly seeds to an even-aged stand which is left until mature enough for the process to be repeated.

True these Indians have a tremendous capacity for hard work and the need for it, but thus far no interfering fools have made them feel sorry for themselves. Nor do they have occasion for self-pity. They live in surroundings that breathe beauty, while their esthetic sense finds full play in superbly designed and colored textiles, ceramics, community life and markets bright with tropical fruits and handcraft.

I suspect that when the chips are down, two great faults will be charged to Western civilization—failure to learn from nature and an unwillingness to learn from simpler cultures which it has disrupted.

What other peoples have accomplished without the benefits of science suggests what we might do once we learn to make technology our servant rather than our master. To that end I propose a question whose answer lies beyond the reach of science, however much science may illuminate the search. If we care what the future may bring forth, what do we desire it to be? Once we know what kind of a world we want, science gives us abundant means to shape it. Let us not forget an ancient warning, "Because thou art neither hot nor cold, I will spue thee out of my mouth."

Paul B. Sears was National President, later called Chancellor, of Phi Sigma from 1928 to 1933. He is past president of the Ecological Society of America and of the American Association for the Advancement of Science and is author of "Deserts on the March" (1935), "This is Our World" (1937), and "Charles Darwin" (1950).

Man Against the Weeds[1]

RICHARD J. HULL

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At no time in the history of the world has there been a greater human population than there is today. Not only is the size of the population staggering, but its rate of increase is such that it may easily double itself within the next century. As this mass of humanity swells the problems of space and food become those of major concern. Although some Western nations are currently enjoying a period of agricultural surplus, the sobering fact that three-quarters of the world's population is suffering from malnutrition leaves little room for complacency. Many economists agree that even in the United States, with its exploding population requiring more and more room for living space, the end of agricultural surplus and the prevalence of actual deficiency is well within the foreseeable future.

Although the enemies of man are frequently considered those that threaten his political ideologies, the day may not be for off when mankind's true enemies will be recognized as those insidious little things that threaten his very existence by limiting his capacity to produce food. These enemies, including the insects, diseases and weeds, have been with man since the day of his creation and continue to plague him today. Man's ability to survive in the face of his ever increasing numbers will depend to a great exent on his success in overcoming these ancient rivals.

Of the three principal agricultural pests, weeds constitute the greatest limiting factor in food production. It has been estimated that weeds are not only the greatest single deterrent to agricultural production, but may actually exceed the combined losses caused by all other pests.

The influence of weeds on human society is exerted in many diverse ways, some of which are difficult to evaluate in terms of dollars and cents. Sufferers of hay fever can attest the misery caused by ragweed and other plants whose pollen causes an allergic reaction in millions of people. Many communities support multi-thousand dollar programs in an effort to eradicate ragweed from residential areas. Hospital and medication expenses evidence the seriousness of the painful dermatitis resulting from contact with poison ivy and related plants. Millions of dollars are spent each year to eradicate unsightly weeds from fine-turf and lawn areas not to mention the effort required to keep vegetable and ornamental gardens free of weeds. The control of vegetation along power lines, railroad tracks and roadsides constitutes a multi-million dollar expense that must be borne by private and municipal agencies. Weeds create serious fire hazards around industrial plants, refineries, and similar sites. Aquatic weeds in drainage and irrigation ditches and canals cause inestimable annual flood losses. Losses amounting to millions of dollars are absorbed by the livestock industry resulting from animal consumption of poisonous plants.

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[1] Reprinted from The Cell, April 1959, issued by the Alpha Xi Chapter of the Phi Sigma Society.

All of the above mentioned losses are small, however, in comparison to those resulting from reductions in crop yields due to weeds. In the United States alone the annual weed "tax" paid by the nation's agriculture has been estimated at over five billion dollars. In Great Britain this loss is on the level of fifty million pounds or 130 million dollars. A proportional figure could be cited for every nation on earth, the significance of which becomes all the more serious in those nations already suffering a deficiency of agricultural products.

Weeds effect this reduction in yields in essentially two ways. The presence of weeds may contaminate the crop resulting in reduced quality if not rendering it completely useless. Rice grown for seed but contaminated by such weeds as curly indigo (*Aeschynomene virginica*) or coffee weed (*Sesbania exaltata*) may suffer a reduction in value as high as $413 per acre. Yields of forage crops obtained during the seeding year are generally worthless because of weed contamination.

The second way that weeds can reduce crop yields is by competing with the crop plants for light, moisture and nutrients. Being idigenous to an area, weeds generally have a competitive advantage over the introduced crop plants. This competition can seriously reduce the vigor and yielding capacity of a crop if not eliminating it altogether. It has been reported that one charlock plant (Brassica sp.) requires twice as much nitrogen, twice as much phosphorus, four times as much potassium and four times as much water as a well developed oat plant. Fifteen such plants per square foot were found to reduce oat yields by 11 bushels per acre in New York. The same weed was observed to reduce wheat yields by 40 percent and a population of seven sow thistle (Sonchus sp.) plants per square foot caused a wheat yield loss of 71 percent.

Weeds can reduce production in still other ways than those listed above. Weeds growing along fences or surviving from the previous year can harbor insects and diseases that may seriously reduce crop yields. Species of wildrye and bromegrass may carry the parasitic fungus *Claviceps purpurea* which causes ergot of rye. This organism can seriously reduce the yields of a rye crop and render it unfit for human or animal consumption. Some weeds have an antagonistic effect on crop plants. The roots of crackgrass (*Agropyron repens*) were found to excrete a toxic material that significantly reduced the vigor of legume crops growing with this weed. Some weeds are parasites of certain crop plants. Witchweed (*Striga asiatica*) is a parasitic plant that attacks corn, sugarcane, sorghum and many other grasses as well as some broadleaved plants. Corn yields in witchweed infested fields in the Carolinas were complete failures in 1956. These last mentioned methods by which weeds inflict crop injury are much less important than those stated earlier, but show the diverse nature through which weeds can become a problem.

The significance of weed injury in agriculture has been recognized for only a comparatively short time. The first effective attempt to control weeds was made early in the 18th century by Jethro Tull. In his "The New Horse-Houghing Husbandry", published in 1731, Tull advanced the concept of growing crops in rows and cultivating between them. Even then he felt that the benefits derived from this practice were due to feeding the crop finely divided soil rather than any weed control that was obtained. Nevertheless, in the years that followed mechanical cultivation became the principal means of controlling weeds. The ever increasing yields obtained from row cultivated crops are due to a great extent to the effectiveness with which weeds can be controlled.

In the meantime no comparable practice was devised to control weeds in those crops not suited to row cultivation. Most affected among these are the world's grassland areas. The lack of a truly effective way of restricting weed growth in grasslands has contributed greatly to the comparatively lower returns obtained from these areas. This lower productivity was most strikingly emphasized in 1957 by Gordon Wrigley when he stated that the 10 percent of the earth's land area that is cropped produces 90 per cent of the world's food supply and the 20 percent of the earth's land area that is covered with grassland produces the remaining 10 percent.

Although much of this underproductivity of our grassland acreage is due to reduced fertility and improper land management, the bulk of the blame must be borne by the infestation of weeds. In South Africa alone two and a half million acres of natural rangeland have been lost to production through infestation by thorn scrub (Acacia sp.) and a further 5 million acres are being endangered. In 1891 the natural pastures of the western division of New South Wales supported over 16 million sheep. During the following ten years of mismanagement and weed encroachment the number of sheep that could be grazed on that area fell to five and a half million and it has been impossible to this day to support half of the 1891 sheep population. In the United States nearly one third of the Texas rangeland is infested with mesquite (*Prosopsis juliflora*) and hence rendered practically useless for grazing. Even intensively managed grasslands such as the alfalfa fields of Washington state have reported an annual loss of one ton per acre due to infestation by downy bromegrass (*Bromus tectorum*). Weed competition is generally acknowledged as the greatest single reason for the all too frequent failure of forage seedings.

For centuries man has been helpless to reduce this loss to his grassland production and restricted to costly mechanical cultivation in most other crops. It was not until 1885 when copper sulfate was found to possess some herbicidal properties that it was considered possible to control weeds by chemical means. Used in a mixture with lime it produced an unsightly paste that was found effective in discouraging the theft of grapes in Bordeaux, France. When high concentrations of this material were used it was found that charlock among other plants was killed. Thus began the use of chemical agents as a means to restrict plant growth. In the years that followed many different salts and acids were used; some of them giving moderately effective results in controlling many broadleaved weeds. These chemicals were for the most part plasmolytic poisons and would destroy any plant with which they came in intimate contact. Any selective properties that might be observed were based on the ability of a plant to resist being wetted by an aqueous solution of the chemical. These materials were dangerous to apply and were often quite costly. Their effectiveness was determined to a great extent by weather conditions since a rain coming shortly after application of the chemical would wash it off the plants rendering the treatment ineffective. The many disadvantages in the use of these inorganic chemicals prevented them from becoming widely used for agricultural purposes.

It was with the advent of the highly selective organic herbicides that weed control through chemical means became practical. The pioneer material of this type was sodium dinitro-o-cresylate, first used as a herbicide in France in 1933 and introduced to the United States in 1937 by Westgate and Raynor at the California Agricultural Experiment Station. There it was found to be highly toxic to many broadleaved plants, but less harmful to grasses. In a relatively short time this material became widely used on grain and other grass crops and as a pre-seeding treatment was found useful in many row crops.

When 2,4-D was released in 1942 the use of herbicides began to pick up momentum. Also, selective against broadleaved plants, 2,4-D requires lower rates of application and is effective against a greater number of weeds than the earlier dinitro compounds. Since then a large number of herbicidal materials have been developed having a total annual sale of over 35 million dollars.

Although the use of these materials is increasing every year most agronomists agree that this is just the beginning. The control of big sagebrush (*Artemisia tridentata*) with herbicides costing $2.25–$3.25 per acre has resulted in a net gain of about $1.68 per acre in Oregon. If such a treatment were applied to one quarter of the 96 million acres of infested rangeland an annual gain of 40 million dollars could be realized. In addition, this treatment is estimated to be effective for at least ten years which would result in a gain ten times as great. In Arkansas an average gain of $67 per acre was obtained from rice in which barnyard grass (*Echinochloa crus-galli*) has been effectively controlled using ClPC. Minnesota reported that controlling weeds in flax with TCA and MCPA gave an average annual gain of $15 per acre over a seven year period. Pre-emergence treatments of Neburon resulted in birdsfoot trefoil yields in excess of two tons per acre during the seeding year in Rhode Island. This is particularly striking when one considers that no useful forage can usually be harvested from this crop during the seeding year.

Substantial yield increases can be had from practically every major agricultural crop through the use of herbicides. The benefits to be derived in world agriculture through the use of these materials has not as yet been determined. Ashby and Pfeiffer stated that while yield increases of about 25 percent were realized from weed control in the temperate zones, in the tropics and sub-tropics yield increases in excess of 100 percent are frequently obtained. What this may mean to the agriculture of certain regions of Asia and Africa can as yet only be imagined.

Along with increases in production the use of herbicides has resulted in almost unbelievable increases in efficiency. According to a recent report to Congress, the efforts of one worker in a chemical plant producing 2,4-D is equivalent to the toil of 4000 farm workers armed with hoes. Onion growers in Colorado currently spend about $60 per acre for hand weeding. Through the use of chemicals the same job may be done for less than one-tenth of that cost. Increases in efficiency on this level cannot fail to result in greater savings for the consumer and larger profits for the producer.

Encouraging as all this may sound, the war against weeds is not over yet. Much of the material presented has been from research findings and not field practice. The application of these techniques to large scale operations must be accomplished before their true value to agriculture can be determined. The dissemination of these herbicides and the knowledge of their use to those nations most able to benefit from them is yet to be accomplished. There are still a number of crops for which there is no effective herbicidal treatment. These are of course relatively small problems. Research has broken through the weed barrier and demonstrated that the problem can be solved. Through the efforts of research workers all over the world the various limiting factors of man's food producing capacity will one by one be removed and the day of a starving humanity never be realized.

SYMMETRY

Even the sponge supposes a symmetry,
Spells a species form to be attained.

Even the snail, forsaking centrality,
Calculates disciplined curves in singular rhythm.

And I? —envision patterns of divinity,
Sustain bleak reason's vertiginous flights beyond sense,

And seek in the great constellations their mystery,—
And mine, dotted in the grid of infinity.

Vera Koehring
Hunter College

Beetles as Pollinators

B. J. D. MEEUSE

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It is not surprising that in many popular books discussions of pollination are confined to the activities of the wind and the bees. The efficiency as pollinators of bees and bumblebees is indeed most impressive. For instance: it has been estimated that one acre of red clover can produce as many as 200 million of the little florets that compose the flowerheads, and practically all 200 million of these are pollinated by bees of some sort! As a pleasant surprise, we occasionally come across a few remarks concerning the role of hummingbirds, hawkmoths, flies and butterflies; however, to see mention made of the beetles is a very rare thing indeed. The omission is deplorable, because—as we shall presently see—beetle-pollination has some very interesting biochemical and phylogenetic implications. The present article is an attempt to correct the situation by presenting some striking case-histories.

One of the oldest cases of beetle-pollination studied is that of the famous "Victoria regia", a water–lily from the Amazon region in Brazil. The correct name is *Victoria amazonica* (Poeppig) Sowerby (Karstens, 1958). In the evening, the flowerbuds of this plant are transformed into beautiful, creamy-white flowers, emitting the sweet and mysterious fragrance of tropical fruit. The production of this smell (which is strongly reminiscent of ethyl-butyrate) is accompanied by considerable heat-production, reaching a maximum between 5 and 8 p.m.; the difference in temperature between the flower and its environment may then be as high as 12.5° C (22.5° F). Knoch, who in 1899 devoted a beautiful study to the Victoria flowers, found that the stamens, the staminodia and especially the appendages of the carpels are the seats of the heat-production. Large quantities of carbohydrate disappear rapidly here; they are obviously used as fuel. The high temperature reached is almost a record in the plant world. As we shall see later, only some members of the arum lily family can put in a better performance.

In their native environment in Brazil, the fragrant, fresh and warm Victoria-flowers will attract large numbers of beetles, related to our June bugs and Japanese beetles. These will be made prisoners, as during the night the flowers gradually fold up. The beetles are very destructive, feeding as they do on the juicy inner wall tissues of their fragrant prison chambers. At the same time, however, they may very well bring about pollination, since the stigmas are in a receptive condition and at least some of the beetles will carry, on their body, pollen picked up during a previous visit to a *Victoria regia* flower. The prisons do not open their doors again until the next evening. The temperature of the flowers, which had dropped to a very low value in the early morning hours, will then again show a considerable rise, although the maximum that is reached is not quite as high as that of the previous night. This time, the development of heat is not accompanied by the production of a fruity odor, and the color of the flowers has changed to purplish, due to the formation of anthocyanin pigments. Just before the blooms open for the second time, the anthers begin to shed their pollen. Thickly covered with this "flowerdust", and no longer held spellbound by fragrance, the beetles now take to their wings again to drop in on another fresh and fragrant Victoria bloom where the story will be repeated.

North Americans are lucky in that they do not have to go to a tropical country to see beetle-flowers in action: spice-bush or Calycanthus is a very excellent example too. Not long ago, Verne Grant made a beautiful study of the flowers and the pollination in the Western species *Calycanthus occidentalis*, a shrub which is not uncommon along streams and in shaded canyons in Northern California. From May to September, the plants produce an abundance of solitary flowers, fairly big, and dark red when they open. Just as in *Victoria regia*, we find a strong odor at that time; in this case, however, it is the heady fragrance of wine. In its structure, the Calycanthus flower can be compared to a cup. It has a large number of free carpels on its inner, hollow surface, and a continuous series of bracts, petals, stamens and staminodia (or sterile stamens) on its outer surface and upper rim. The various flower-parts are arranged in a spiral, and in the bud-stage they are bunched very close together, overlapping and covering each other, somewhat like the tiles on a roof. When the stigmas are ready to receive pollen, the outer petals will spread out; the inner ones, however, instead of following suit, retain their position to form a central cone with a very narrow opening on top, more or less like a crater. This provides an excellent vent for the odor, and indeed it does not take long for the flower to lure into the dark crater-depths a number of tiny beetles, about 3 mm long, belonging to the family of the flower-beetles or Nitidulidae. As many as 8 or 10 of these *Colopterus truncatus* beetles are sometimes found in one flower! Getting in is easy for them, as the inner surface of the petals forming the crater is covered with small bristly hairs which point downwards. They can also crawl upward on the staminodia and stamens which bear similar bristles pointing skywards. But of course getting out of the flower is another matter, and getting down to the very base of the pistils (where the beetles might do a great deal of damage to the ovules) is likewise made very hard or impossible by a dense growth of long hairs at the base of the staminodia. So, the insects are kept trapped in the flowers at a certain level. But they are well-fed: the upper part of the innermost petals, the stamens and staminodia, and even the receptive tip of each stigma consists of a pearly-white, nutritive tissue. There is no reason, then, why the tiny Colopterus beetles should leave. After 12 to 36 hours (probably depending somewhat on the weather), the anthers will open and shed their pollen, dusting the beetles. The stigmas, however, are protected against self-pollination by the inner staminodia which, in the meantime, have bent inwards, placing themselves over the stigmas like so many shields. Still a few hours later, the cone-forming petals will bend outwards a little way, so that the flower is now more open. The succulent tissue withers, the fragrance disappears almost completely, and the petals fade and turn brown. The Colopterus beetles, no longer interested, take to their strong wings to repeat their performance in another Calycanthus-flower.

Verne Grant considers it very likely that, in spicebush, fertilization does not occur unless some animal carries pollen from one flower to the stigmas of another. Bees and flies do not seem to pay attention to Calycanthus-flowers (and, incidentally, they would be too big to enter anyway). Thus, the spicebush-flower is entirely dependent on Colopterus for its pollination. The beetle, on the other hand, has been reported from various localities between Canada and Brazil, where spicebush is not always found, and must be considered as able to fend for himself.

Other beetle-flowers in the American flora are magnolias and peonies and at least some of the water–lilies. It is interesting that it should be just exactly this primitive group of plants (the so-called Ranales) that has connections with beetles (Diels, 1916). These latter insects, namely, are also considered to be "old" or "primitive". They were already highly developed in the mesozoic geological period, when they must have formed more than a third of the total insect fauna; more than 400 mesozoic beetles species have thusfar been described (see, for this, Carpenter (1930) and Handlirsch (1925)). In those days, there were only very few flies and bee-like insects, and no butterflies or moths to speak of. These latter, and other flower-lovers such as true bees and wasps, bee-flies and syrphid flies, did not really get their start until the early tertiary period. In other words:

in the ancient days when the flowering plants just began to appear, beetles were practically the only insects that were around and could enter into any relationship with them! Perhaps it is not a coincidence that there is at least one beetle-pollinated cycad too: *Encephalartos villosus.* Verne Grant believes that Cycadoidea, the mesozoic ancestor of the cycads and perhaps of the flowering plants as well (see Wieland, 1906), was also beetle-pollinated. According to him, it had many features in common with our present-day Calycanthus, such as the presence of a trap-like structure and the fact that the female organs reached maturity before the stamens did so.

Be that as it may, from the point of view of pollination the performance of the group of the beetles has certainly been somewhat disappointing after their promising start. Although nowadays there are at least 300,000 beetle species (new ones are still being discovered every day!), only a very few of these have managed to develop mouth-parts resembling those of bees and butterflies. Especially fascinating, in this connection, are the species of the genus Nemognatha in the family of the blister-beetles. Nemognatha (literally: thread-jaw) (fig. 1) occurs in tropical and subtropical America, with several species in Oregon and Washington. The maxillae or lower jaws are developed to such an extent that in many species they are longer than the body! Each maxilla bears a straight, almost saberlike, appendage (fig. 1). The inner, hair-covered margins of the appendages touch each other, so that a sort of gutter is formed through which nectar can move to the beetle's mouth with the aid of capillarity. Actually, the gutter can fairly be compared to the proboscis of a butterfly, since the mouthparts that form the structure are the same in both cases. However, the gutter of Nemognatha cannot be coiled and uncoiled like the magnificent instrument of the butterfly, and the mechanism of sucking is different too.

Most other beetles have 2 pairs of biting jaws and a short lower lip, so that they cannot get the nectar from deep, tubular flowers. The best they can do is to crush pollen-grains with their jaws and lap up exposed nectar with the hairy parts of their mouths. The proper places to look for flower-visiting beetles, therefore, are the flat inflorescences of Umbelliferous plants such as wild carrot and cow parsnip, those of elderberry, Spiraea, etc. We find the beetles here in the company of various flies. Indeed, there is some similarity between the two groups as far as feeding-habits are concerned! Although there are some notable exceptions such as the fuzzy beefly, Bombylius, which is a marvelous pollinator, it is fair to say that the flies as a group, just like the beetles, have failed to respond to the challenge offered them by the flowers in the process of evolution. Sprengel, the great pioneer in the field of pollination, was keenly aware of the deficiencies of the flies. It is amusing to compare his annoyance with the "dumb" flies, as he frequently calls them, and his admiration for the "intelligent" bees. The latter are persuaded to offer their valuable pollination-services by offering them attractive colors, smells and nectar; the "stupid" flies, on the other hand, can only be fooled, trapped and incarcerated. It is clear that the examples of beetle-pollination which we have given here are based on the trap-idea too. Still, we feel that it is justified to present a final case which demonstrates the similarity between "dumb" flies and "dumb" beetles to the hilt. In the arum lily family, we see that *the same sort of trap* can be used for the two groups of animals!

In 1926, Knoll published the results of his charming studies on certain European arum lilies, including *Arum maculatum*, common in Central and Western Europe, and *Arum italicum*, a Southern European species which in some places (Florence!) is so abundant that it is considered a weed. The "flowers" of these plants are, in reality, complete inflorescences with separate groups of staminate (or male) and pistillate (or female) flowers. In addition, there are sterile, hair- or bristle-shaped flowers. The situation is illustrated by fig. 2. At the time when a "flower" opens, it has a very unpleasant, carrionlike odor, originating in the naked upper part of the inflorescence, the so-called appendix. The temperature in the floral chamber may be 15–20° C higher than that of the environment, and only the female flowers at the base of the central column are mature, i.e. ready to receive pollen. Each female flower has, for a stigma, a whitish brush which at this stage is completely wet with a slimy, sweet fluid. If, at this time, an Arum flower is cut open, a whole cloud of small gnats will emerge; as many as 4,000 have been obtained from one single chamber! These animals belong to the group of the Psychodidae. However, careful examination of the floral chambers will as a rule reveal that some minute beetles, usually Staphylinids, are also present. It is clear that these gnats and beetles

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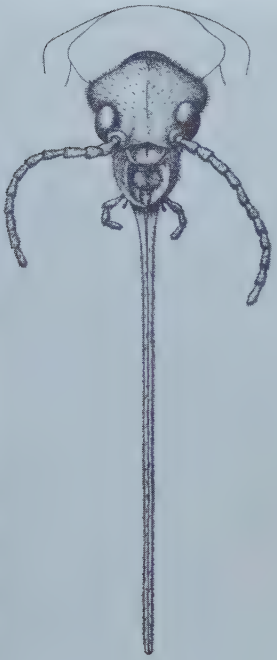
Fig. 1. Upper left. Front view of the head of a Nemognatha beetle. Two saberlike appendages (one on each maxilla) form a gutter, suitable for the uptake of nectar.

Fig. 2. Upper right. Floral chamber of *Arum maculatum*, showing the arrangement of bristles, male flowers and female flowers. The latter are placed at the base of the central column; the male flowers are placed higher up, separated from the female flowers by a zone of bristles (modified, sterile flowers).

Fig. 3. Lower left. *Amorphophallus titanum*, a giant Arum lily from Sumatra. Pollinated by carrion beetles.

Fig. 4. Lower right. Floral chamber of *Dracunculus vulgaris*, cut open to show arrangement of male flowers (above) and female flowers (below). Pollinating beetle (Saprinus spec.) visible.



Figs. 1–4

were kept as prisoners; somehow they must have been attracted and trapped by the "flowers". It can easily be demonstrated that it is the carrion smell of the appendix that attracts the insects. When, namely, a glass model of the Arum "flower" is provided with a cut-off, fresh appendix, or otherwise with some decaying blood, it will accumulate in its chamber large numbers of the same sort of insects found in the natural "flowers". Larger flies and beetles are discriminated against: the brush of hairs just above the male flowers serves as a sieve or collander holding them back. A legitimate question to ask is, why the small gnats and beetles do not stay in the upper, exposed part of the arum lily inflorescence, if it is really the appendix which attracts them? The answer is that the insects *fall* in, because they cannot find a foothold, not even a toehold, on the walls of the spathe. At first sight, this seems hard to believe, because it is known that many insects are past masters when it comes to the matter of hanging on to difficult surfaces. On a somewhat rough surface, flies use their claws; on a very smooth one, the suction-cups with which their feet are also equipped. In spite of this, the arum "flower" is able to cope with the insects because the inner surface of the spathe is provided with countless tiny droplets of oil. This renders the animals utterly helpless, and the small flies, falling down through the bristles above the male flowers, will end up in the floral chamber. Escape from here is impossible: the walls of the chamber are just as smooth and slippery as the upper spathe surfaces, and when the insects try the alternate path upwards across the female flowers, they find themselves blocked by the lower barricade of brushes depicted in our figure. However, the animals are well provided with food in the form of the slimy stigma-secretion which we have already mentioned. If they happen to have some Arum pollen on their bodies when they came in, part of that will be left behind on the stigmas, where it soon begins to germinate. During the hours of darkness, the insects which have had so much oportunity to gorge themselves will usually quiet down. But now the stamens of the male flowers will gradually open, and the insects in the chamber will be bombarded with a steady rain of pollen grains from above. The next morning, therefore, they will find themselves "tarred and feathered". Resuming their efforts to escape, they discover that the chamber walls are just as forbidding as before, but the barrier-organs (the bristles) have lost their stifness; they have wilted a little and expose a wrinkled surface so that the insects' claws seem to have much more bite. Thus, the gnats can crawl upwards, leaving the female flowers behind; they cross the zone of the male flowers and the uppermost region of bristles (which have also wilted) to find themselves, at long last, in the open. The appendix at this time has lost its carrion smell, and the prisoners fly off. However, as soon as they notice the smell of another Arum "flower" which is in the female stage, they will be attracted, and in a short while they will again be effecting pollination, in another prison chamber.

It cannot be denied that, in the case of the Arums we have just discussed, the accent is heavily on the Psychodid flies. We have dealt with it so extensively only because Knoll's work has all the qualities of a classic, enabling us to understand without too much trouble the other cases we encounter in the Arum lily family. In some of these, beetles definitely are the preferred pollinators. In *Arum dioscoridis,* for instance, a plant native in Lebanon, Kullenberg has recorded as the most important visitors the following beetles: *Philonthus intermedius* Boisd., *Oxytelus sculpturatus* Grav., *Onthophagus ovatus* L., *Onthophagus sellatus* Kl., *Oxyomus silvestris* Scop., *Aphodius signifer* Muls. & Rey, and *Cercyon haemorrhoidalis* var. *discoidalis* J. Sahlb. All of these are species usually found on dung or carrion!

Amorphophallus titanum from the jungles of Sumatra produces a "flower" 8 to 10 feet high (fig. 3). This plant has bloomed at the famous Botanical Gardens at Kew, England, in 1926; also in Hamburg and Wageningen, and in this country at the New York Botanical Garden in 1937 and 1939 (see Everett, 1950). The carrion-odor is so overpowering that some people are known to have fainted when they came too close. In nature, the pollinating carrion-beetles are again trapped in a flower-chamber; in this case, escape is made impossible not by a system of bristles, but by a very sharp edge or keel on the central column of the inflorescence. Much more common is a smaller Amorphophallus-species, *A. variabilis,* which is referred to by the Indonesians as "kĕmbang bangkè" (literally: carrion-flower). The small beetles that take care of pollination here are held for no less than 5 days, in spite of the fact that there is no real trap as in the case of the spotted Arum. The reason is that the plant offers them, at the bottom of the spathe, an edible layer so delicious that there is no advantage in leaving. Just by the time this layer begins to rot, the pollen-rain starts to fall down on the beetles, so that they sally forth on their quest for another inflorescence loaded with pollen grains (see Van der Pijl, 1950).

A case of beetle-pollination in Arum lilies with which American city-dwellers can more easily familiarize themselves is that of *Dracunculus vulgaris,* known in some circles as dragon lily, black calla or black lily of the Nile. Although is it found naturally only in the Northern Mediterranean region, from Portugal to the Western part of Asia Minor, this plant has found its way to many American gardens; it is very popular and successful in Seattle, where it flowers around the middle of June. *Dracunculus vulgaris* and its variety *creticus* from the island of Crete possess the largest "flowers" in the European flora. The average size is 1–2 feet, but inflorescences that are 3 feet tall are by no means rare. The inside of the spathe has a beautiful, purplish-black color. The appendix is even darker, having the glossy appearance of black cherries. The spathes of Dracunculus open in the morning hours. Although the heat-development is not impressive—the reason for this being that the appendix is hollow and thin-walled, so that there just is not enough fuel to burn—the smell, which reminds one of long-dead fish, is overpowering. The air soon is abuzz with flies attracted by the appendix, and some of the animals are fooled by its odor to such an extent that they will deposit their eggs on this organ. However, the entrance to the flower-chamber is rather narrow and most of them do not enter. Small beetles, on the other hand, can soon be found in the flower chamber by the dozen. As can be expected, they are of the type usually found on carrion, such as *Saprinus* (Histeridae) (fig. 4) and *Nitidula carnaria* (Nitidulidae), or on dung, such as *Platystethus americanus* Er. (Staphylinidae). Schmucker, in 1930, has compiled similar information for *Dracunculus creticus* in its native habitat. It is interesting to note that in Seattle and in Crete the same families are represented, and that in 4 cases the same genera are involved! The selecting agent must be the smell of the appendix. Yet it should not be concluded that the dark spathe has no function at all. The present writer has obtained some evidence that a large, dark surface of this sort invites insects such as flies to sit down, once the proper mood has been induced in them by the smell. Working on the same problem and using about 500 inflorescences, Schmucker has found that about 65% of his *intact* plants produced fruits successfully, against only 35% of the plants in which the spathe had been amputated. For plants that had undergone "appendectomy", the rate of success was 25%—not much worse than that of the spathe-less plants! Of the plants devoid of both spathe and appendix, only 8–10% produced fruits.

The rest of the pollination-story in Dracunculus is very much like that in *Arum maculatum*. The anthers, which reach maturity later than the pistils do, will eventually bombard the visitors with pollen. The fishy smell disappears, so that the next day there will only be a faint aromatic odor, reminiscent of the smell produced when the caterpillars of certain Papilio butterflies stick out their little scent-fork. The number of beetle-visitors in the flower-chamber now dwindles rapidly.

We can only marvel at the wonderful timing of the events that take place in the inflorescences of Arum lilies. Some of them can indeed be used as clock-flowers, since they always begin to produce their smell at a certain hour. The above-mentioned kĕmbang bangkè from Indonesia, for instance, will do it at 4:30 p.m. Van der Pijl, who like Knoll has done excellent work on Arum lily "flowers", has found how in this case the chain of events is triggered. It is the change from darkness to light, at 6 a.m. in tropical countries, which starts a chemical process that results in the production of smell 10½ hours later. Thus, to obtain plants that begin to smell at (say) 3 p.m., it is sufficient to put them in the light a few hours before daybreak. Likewise, if it is desired to start them at 7 p.m., they should be kept in darkness until about 9 a.m.

Van Herk, who has written a thesis on the biochemical events in the inflorescences of *Sauromatum guttatum* from N.W. India and Pakistan, has demonstrated that in this plant the process in which heat and stench are produced is started by a hormone, calorigen, originating in the male flower-primordia. It begins to leave these primordia about a day before the inflorescence unfolds. No heating will, therefore, occur if the male primordia are removed one day or more before the expected opening-time; however, if the critical moment has passed, the avalanche has started and removal cannot change the picture at all.

It is almost superfluous to point out that there is a beautiful correspondence between the behavior of the inflorescence and the habits of the natural pollinators. Many carrion-beetles reach a peak of activity in the afternoon and early evening; it is therefore quite meaningful for the kĕmbang bangkè to begin its smell-production at 4:30 p.m.

From the above remarks, it is quite clear that in order to understand the floral mechanisms of beetle-flowers completely, close cooperation between entomologists, behaviorists, botanists and biochemists is required. If the present article helps in bringing about such a cooperation, it will have fulfilled its purpose.

References

Carpenter, F. M. 1930. A review of our present knowledge of the geological history of the insects. Psyche *37:* 15–34.

Diels, L. 1916 Käferblumen bei den Ranales und ihre Bedeutung für die Phylogenie der Angiospermen. Ber. Deutsch. Bot. Ges. *34:* 758–774.

Everett, T. H. 1955. Interesting observations on Amorphophallus titanum contained in certain garden correspondence. Garden Journal New York Bot. Garden *5:* 122, 125–126.

Grant, V. 1950. The pollination of Calycanthus occidentalis. Am. J. Botany *37:* 294–297.

Handlirsch, A. 1925. Palaeontologie. In C. Schröder, Handbuch der Entomologie, Jena, *3:* 117–306.

Karstens, W. K. H. 1958. Victoria amazonica (Poeppig) Sowerby, alias de Victoria regia. Vakbl. Biol. *38:* 37–51.

Knoch, E. 1899. Untersuchungen über die Morphologie, Biologie und Physiologie der Blüte von Victoria regia. Bibl. Bot. *9, 47:* 1–60.

Knoll, F. 1926. Die Arum-Blütenstände und ihre Besucher. Abh. Zool.-Bot. Ges. Wien *12,* Heft 3.

Kullenberg, B. 1953. Observationer över Arum-pollinerare i Libanons kustområde. Svensk Bot. Tidskr. *47* (1)*:* 24–29.

Schmucker, Th. 1930. Blütenbiologische und -morphologische Beobachtungen. Planta *9:* 718–747.

Schrottky, C. 1910. Die Befruchtung von Philodendron und Caladium durch einen Käfer (Erioscelis emarginata Mann.). Zeitschr. Wiss. Insektenbiologie *6:* 67–68.

Sprengel, C. K. 1793. Das entdeckte Geheimniss der Natur im Bau und in der Befruchtung der Blumen. Berlin.

Van Herk, A. W. H. 1937. Die chemischen Vorgänge im Sauromatumkolben. Thesis Amsterdam.

Van der Pijl, L. 1950. Met open ogen door stad en land. Jakarta-Bandung-Semarang-Surabaia.

Wieland, G. R. 1906. American fossil cycads. Carnegie Inst. Washington Publ. *34.*

The Editor Speaks

THE Editor is happy again to present a contribution, "Man Against the Weeds," from The Cell, a mimeographed annual issued by the Alpha Xi Chapter at the University of Rhode Island. It would be a splendid idea if other chapters would bring the talents of their membership to the fore in a similar fashion.

The present paper, by Richard J. Hull, reveals weed control as taking its place along with insect control, crop rotation, use of fertilizers, etc. as bringing about the more efficient production of crops. It is a mistake, however, to suppose that such methods by themselves can solve the problem of human food. Man's reproductive capacity can more than use all the food that the agriculturalists can produce. Only when man brings his population into a steady state of some sort relative to the environment, as envisaged by Paul Sears in another paper in this same issue, will the problem of human hunger be on the way to solution.

Book Notices

The Growth of Modern Thought and Culture. HERBERT WENDER; 1959. Philosophical Library, Inc., New York. 213 pp. $3.75.

This is an interestingly written fast moving account of the last 500 years of Western Culture. The reviewer was gratified to note how frequently Dr. Wender selected precisely those names for comment that he would have selected himself. There is no bibliography, telling the reader where to go next, and no index, and one cannot help but wonder whether the book is not more useful as a review than as an introduction! If there is criticism, it is at the slight attempt to correlate cultural with political and economic history.

The reviewer finds few things to take exception to. He feels (p. 34) that a reading of Singer's *Giordano Bruno* (1950) shows that Bruno was executed "not so much for his science, as for his philosophy and his zeal for religious reform" (Dampier, History of Science 1942, p. 124) and his theological views.

Again (p. 188) it is a bit incongrous to find de Vries and his mutation theory the only thing mentioned for twentieth century biology. If one name is to be selected, it should be Thomas Hunt Morgan of Columbia University and his theory of the gene. De Vries' theory was a misinterpretation of a case of hybrid variability and the multiple minute mutations of modern genetics are almost the precise equivalent of the individual variations that Darwin assumed as the main basis for the action of natural selection.

The Challenge of Science Education. Edited by JOSEPH S. ROUCEK; 1959. Philosophical Library, New York. 491 pp. $10.00.

A collection of over 30 chapters on different aspects of science education in the United States. Among the collaborators are such eminent men as Dr. James R. Killian, consultant to President Eisenhower. Dr. Werner Heisenberg of the Max Planck Institute for Physics in Munich contributes the concluding essay on "Classical Education, Science and the West." Sections on Biology by Carl S. Johnson of Ohio State University and Zoology by W. R. Murchie of the Flint College Branch of the University of Michigan especially concern the biologist.

Magnets: The Education of a Physicist. FRANCIS BITTER. 1959. Doubleday & Co., New York. 155 pp., 27 figs. 95¢

Soap Bubbles and the Forces which Mould Them. C. V. BOYS. Doubleday & Co., New York. 156 pp., 15 figs. 95¢

Echoes of Bats and Men. DONALD R. GRIFFIN. 1959. Doubleday & Co., New York. 156 pp., 15 figs., 95¢

The Neutron Story. DONALD J. HUGHES. 1959. Doubleday & Co., New York. 158 pp., 39 figs. 95¢

These four "paper backs" in the Doubleday Anchor Science Study Series represent a laudable attempt to make available to general readers authoritative writings on various aspects of physical science. Three of the books are originals. The book on *Soap Bubbles* by Sir Charles Vernon Boys (1855–1944) is a reprint of a classic first published in 1902, with a revised edition in 1916.

How Old is the Earth? PATRICK M. HARLEY. 1959. Doubleday Anchor Books, New York. 160 pp. 95¢

An interesting summary of earth structure and the various sorts of evidence leading to an estimate of its age. The method of calculating the age of rocks from their radioactive content is explained giving an age of about 2.8 billion years for the oldest rocks, a minimum age of about 4.5 billion years for the separation of the earth's stony mantle from its iron core, and an age of 6.5 to 7 billion years ago for the time of formation of the elements in our part of the universe. The author likewise stresses the role of heat energy derived from radioactive materials in the earth in bringing about the initial separation of the stony mantle from the iron core and the role of the same energy in the formation of the gradually expanding continents and in mountain formation. Most instructive reading for the biologist who would know something of the environment in which living things have developed.

Natural Selection and Heredity. P. M. SHEPPARD. 1958. Philosophical Library. New York. 212 pp.

This book deals particularly with the role of natural selection in producing many of the aspects of plants and animals of especial interest to the systematist. Polymorphism, polygenic inheritance, gene drift, dominance, protective coloration, and mimicry are among the topics stressed. It is a book that stresses anew the complete competence of natural selection to account for evolution. Many of the author's examples are drawn from the moths and butterflies, and he makes a telling case of industrial melanism in England.

The author is a Naturalist deeply imbued with nature. He tells (p. 192) of the European Large Blue butterfly, *Maculinea arion* (L.) who larvae feed for the first few weeks on Wild Thyme. They produce a sweet fluid that induces ants to take them into their nests, where the caterpillars mature by feeding on ant larvae!

Sheppard also calls attention to a passage in Darwin's Animals and Plants under Domestication, 1868 (vol. II, p. 70–71) that may be as surprising to the reader as it was to the reviewer. Darwin crossed peloric snapdragon with the common form securing only the common form. These, when allowed to self pollinate gave 88 common, 2 "intermediate," and 37 peloric, a 2.3 ratio between common and peloric. With this perfect example of particulate Mendelian heredity right before his eyes only two years after Mendel's paper, Darwin for all his genius, continued to hold to blending heredity!

The Molecular Basis of Evolution. CHRISTIAN B. ANFINSEN. 1959. John Wiley & Sons, Inc. New York. 228 pp., 99 figs., 17 tables.

Most of us realize that a major aspect of mutation is concerned with events at the molecular level in the process of the reduplication of the chromosomes and that before we can know much about the causes of the failure of precise reduplication, we must know considerably more than we do about the molecules themselves. Such structures are so extremely minute that only by the most devious and circumstantial evidence are biochemists and students of bacteriophage genetics crawling up on possible answers. This book is an account by a biochemist of some of the current investigation and hypothesizing in this field. If the results are inconclusive it is only because it deals with researches still in mid-course. If the going is heavy to a non-biochemist, it is only a reminder that an adequate appreciation of biochemistry is an integral part of present day botany and zoology. Essential reading.

Genetics, Radiobiology and Radiology Proceedings, Mid-Western Conference. Edited by WENDELL G. SCOTT and TITUS EVANS. 1959. Chas. C Thomas, Springfield, Ill. 149 pp., illus. $5.50.

This is a collection of 15 papers by 14 different investigators. Its purpose is to develop a better understanding of the problems arising from the medical use of ionizing radiation among the geneticists, radiobiologists, and radiologists.

Textbook of Microbiology. 17th Edition by WILLIAM BURROWS with the collaboration of RICHARD JANVIER PORTER and JAMES WILLIAM MOULDER. 1959. W. B. Saunders Co., Philadelphia. 954 pp. 301 figs.

This is the 17th Edition of a book first published in 1908. It is a detailed comprehensive treatment to which one can turn for both the older and newer aspects of the subject.

Laboratory Manual for General Bacteriology. 5th Ed. by GEORGE L. PELTIER, CARL E. GEORGI, and LAURENCE F. LINDGREN. 1959. John Wiley & Sons, Inc., New York. 295 pp. $4.50.

Microbiology. Second Edition By LOUIS P. GEBHARDT and DEAN A. ANDERSON. 1959. C. V. Mosby Co., St. Louis. 476 pp., 69 figs. $5.75.

An elementary text for undergraduates.

Microbiology—Yesterday and Today. Edited by VERNON BRYSON. 1959. Institute of Microbiology, Rutgers University, New Brunswick, New Jersey. 122 pp. $4.

This book consists of seven papers presented at a symposium held in honor of the seventieth birthday of Selman A. Waksman, Nobel Laureate and Professor Emeritus, Institute of Microbiology, Rutgers University, June 5, 1958. Such topics as microbial biochemistry, antibiotics, immunochemistry, classification, genetics, and Russian microbiology are considered, the book concluding with an essay by Dr. Waksman whose title became the title of the book.

An Introduction to Bacterial Physiology. Second Edition by EVELYN L. OGINSKY and WAYNE W. UMBREIT. 1959. W. H. Freeman & Co., San Francisco. 443 pp., illus. $7.50.

This is a textbook designed for use in an undergraduate course immediately following an introductory course.

Virus. WOLFHARD WEIDEL. 1959. The University of Michigan Press, Ann Arbor. 159 pp. $4.50.

Continuing a forward-looking effort to bridge the gap between the scientist and his supporting public is *Virus*. This book is the 10th in the series, "Ann Arbor Science Library". As its predecessors, it is the translation of a work originally published (1957) by the Springer Press in Berlin.

Contentwise this small book provides a sound informational basis for both the laymen and the beginning technical worker. Good coverage is accorded to such topics as: What is a virus, modern methods of laboratory studies in virology, comparative structure and physiology of virus and cell and virus disease. Challenging problems are cited (e.g., autocatalytic reproductive systems) as are opportunities and goals for future research. The choice of "The Love Life of Viruses" as a title for Chapter 5 reveals a bit of overenthusiasm, the desire of the translator and publisher to sell "science". The high quality of the paper and binding in this little volume strongly affect its selling price and may deter attainment of the objective of widespread public use.—*Karl F. Lagler*

Perspectives in Virology. Edited by MORRIS POLLARD. John Wiley & Sons, Inc., New York. 312 pp. $7.

This symposium will be of special interest to virologists, microbiologists, and medical men. Twenty specialists participated, meeting with others in memory of Dr. F. R. Beaudette (1897–1957) of Rutgers University, who had died of cancer the year before. A portrait of Dr. Beaudette and an appreciation by Selman A. Waksman introduce the volume. Such topics as "Virus Transformation and Cancer," "Recent Advances in Knowledge of the Measles Virus," "70 Newly Recognized Viruses in Man," "The Natural History of Hog Cholera," "Asian Influenza," and "Tulipomania and the Benevolent Virus" indicate the range of subject matter.

The Road to Man. HERBERT WENDT, translated from the German by HELEN SEBRA. 1959. Doubleday & Co., Inc. Garden City. 431 pp. 208 figs. $5.95.

This is a thoroughly satisfactory modern version of the old fashioned natural histories so treasured by the reviewer when he was a boy. The arrangement is roughly by habitats, but with more than a trace of phylogenetic groupings: marine life; amphibians and reptiles; insects, spiders, birds, and bats; mammals ending with a chapter on primates—but there is some mixing along the way. The figures, whether of protozoans, of male stag beetles fighting, of spiders, or of elephants or rhinoceroses are equally fine. There is no bibliography, but there is a good index.

Codfish, Cats, and Civilization. GARY WEBSTER. 1959. Doubleday & Co., Inc. Garden City. 263 pp. $3.95.

This is a modern version of the humanistic natural history that was characteristic of the renaissance. In about a score of simply written chapters, the author tells the cultural history of a series of animals ranging from leeches, potato beetles and cotton boll weevils to starlings, rats, and pigs—the latter an animal whose only use to man is after he is dead! In actual life, the author is Webb Black Garrison, Methodist Minister and president of McKendree College, Lebanon, Illinois. He does not, however, allow conservative theology to keep him from a satisfactory account of Darwinism and evolution. Other than a complete lack of bibliography, I find little to criticize.

Malthus' *Essay on Population* is scarcely a "thin" volume (p. 234); it occupies 600 pages in the Everyman Edition. And it is too bad to perpetuate (p. 168) the myth of the efficacy of transporting lady beetles from the mountains for the control of plant lice. Davidson, in the Transactions of the American Entomological Society (vol. 50, 1924, pp. 163–175) demonstrated that the beetles disperse too rapidly upon being released to have any appreciable influence on the aphid populations. His results have never been challenged in scientific circles.

We Come from the Sea. HANS HASS, translated from the German by ALAN HOUGHTON BRODRICK. 1959. Doubleday & Co., Inc. Garden City. 288 pp. 96 figs. $6.50.

This is a swiftly moving narrative of three expeditions by the author and his wife Lotte in search of skin diving adventures and under water moving pictures. The Sudan coastal coral reefs of the Red Sea, the Great Barrier Reef of Australia, and the Azores and the Curacao and Galapagos Islands off South America are the principal places visited. A concluding chapter on skin diving will interest devotees of that sport and an appended list of fishes and birds will enable the zoologist to fix precisely most of the animals mentioned. An attractive book.

Practical Biology for Advanced Level Medical and Intermediate Students. A Laboratory Manual. Vol. I: Practical Zoology. C. J. WALLIS. 1959. Chas. C Thomas, Springfield, Ill. 317 pp. 175 figs. $5.75.

Laboratory Exercises in Animal Biology. 5th Edition by DALE C. BROUNGART. 1959. C. V. Mosby Co., St. Louis. 255 pp. $3.50.

To accompany the author's *Introduction to Animal Biology.*

Histochemical Technique. W. G. BRUCE CASSELMAN. 1959. John Wiley & Sons, Inc., New York. 205 pp. $3.25.

This, one of Methuen's Monographs on Biological Subjects, deals with various methods available for the identification of substances present in microscopic sections of tissues.

Statistical Methods in Biology. NORMAN T. J. BAILEY. 1959. John Wiley & Sons, Inc. New York. 200 pp. $4.50.

Elementary Statistics with Applications in Medicine and the Biological Sciences. FREDERICK E. CROXTON. 1959. Dover Publications, Inc., New York. 376 pp. $1.95.

These books provide the student an elementary account of statistical methods. The volume by Croxton is a corrected republication of a book first published in 1953. The increasing current use of statistical and biometrical methods in biology should make these books of great interest to many biologists.

Handbook of Toxicology. Vol. III. Insecticides. WILLIAM O. NEGHERBON. 1959. 854 pp. $14. **Vol. IV. Tranquilizers.** MAXWELL GORDON, R. F. J. McCANDLESS, S. W. LIPSMAN, and RUDOLPH M. GREBE. 1959. 120 pp., $14; **Vol. V. Fungicides.** EVERETT F. DAVIS, BARBARA L. TUMA, LUCY C. LEE, and DOROTHY S. DITTMER. 1959. 242 pp., $5.50. Saunders. Philadelphia.

These books were prepared under the direction of the Committee on the Handbook of Biological Data, Division of Biology and Agriculture, The National Academy of Sciences, The National Research Council. They consist of elaborate technical accounts of the various chemicals involved (188 insecticides, 26 tranquilizers, 196 fungicides) with details of chemical structure, preparation, and uses and precautions to be observed in connection with each. Extensive bibliography.

Plants and Environment. A Textbook of Plant Autecology. Second Edition by R. F. DAUBENMIRE. John Wiley & Sons, Inc., New York. 422 pp. $6.95.

Under such headings as soil, water, temperature, light, air, fire, and other plants and animals the author provides a basic treatment of the relation of the plant to its environment. As the last word in the title suggests, the book is replete with terminology, but this is to the good if the book is properly to introduce its field. Such tidbits as "zoochory" (dissemination of plants by animals) with its "endozoochores" ("disseminules" ingested by animals but not digested) and "epizoochores" (inedible disseminules like burs—a "disseminule" is a detached reproductive structure suitable for dissemination) suggest that the words necessary to discuss plant autecology may rival in wonder the facts and relationships themselves! The book is illustrated by many excellent photographs.

The Plant Kingdom. A Laboratory Manual. PAUL C. LEMON and NORMAN H. RUSSELL. 1959. C. V. Mosby Co., St. Louis. 176 pp. 19 plates.

An introductory manual.

Vascular Plants of the Pacific Northwest. C. LEO HITCHCOCK, ARTHUR CRONQUIST, MARION OWENBEY and J. W. THOMPSON. Part 4: Ericaceae through Campanulaceae. 1959. University of Washington Press. Seattle. 510 pp., 112 plates. $12.

This is Part 4 of a five part series; Part 5 appeared in 1955; Parts 1, 2, and 3 are in preparation. The work when complete will offer the first complete guide, with keys, descriptions, and figures of all the species of the ferns, fern-related, and seed-bearing plants of the area between southern British Columbia, Washington, northern Oregon, Idaho north of the Snake River, and the mountainous western part of Montana. Some 4,000 species will be described and pictured in the complete work. Part 4 includes many of the plants most useful as ornamentals.

Fruit Key to Northeastern Trees and Twig Key to the Deciduous Woody Plants of Eastern North America. WILLIAM H. HARLOW. 1959. Dover Publications, Inc. New York. 50 + 56 pp., illustrated. $1.25.

This is a reprint of two booklets published in 1946 and 1954. A useful work, especially to young students seeking an entrée to the art of using keys.

Free-Living Nematodes and Other Small Invertebrates of Puget Sound Beaches. WOLFGANG WIESER. 1959. University of Washington Press. 176 pp., 46 plates, map. $4.

The author of this book is a young Austrian zoologist who spent the year 1955–1956 as a guest at the University of Washington. While here, he investigated the fauna living between the sand grains of certain Puget Sound beaches. This book was one of the results.

The first 97 pages of the book consist

of descriptions of about 120 species of Nematoda from Puget Sound of which over 80 are described as new. Accompanying many of the descriptions are notes, keys, and revisions of old keys relating the presently described species to the author's previous studies in Sweden and elsewhere. Part II (pp. 99–117) treats of the distribution of the nematodes and related species in the sand of the beaches includes one species of Hydrozoa, 5 Gastrotricha, 4 Archiannelida, 4 Polychaeta, 31 Copepoda, 7 Ostracoda, 3 Cumacea, 6 Amphipoda, 1 Chelifera, and 1 Isopoda plus numerous other species identified only to genus. This book represents the type of basic faunal work so badly needed in the Puget Sound area.

Comparative Anatomy. WILLIAM MONTAGNA. 1959. John Wiley & Sons, Inc., New York. 397 pp., 233 figs. $6.

A Laboratory Manual of Comparative Anatomy. WILLIAM MONTAGNA and WALTER KENTWORTHY. 1958. John Wiley & Sons, Inc., New York. 103 pp., $2.50.

These two books cover the subject of vertebrate anatomy. The treatment is largely by systems of organs.

Manual of Comparative Anatomy. A General Laboratory Guide. BRUCE M. HARRISON. 1959. C. V. Mosby Co., St. Louis. 353 pp. 122 figs. $3.95.

Separate sections treat of the dogfish, necturus, turtle, pigeon, and cat. The book concludes with 13 pages of review questions and 19 page glossary.

A Manual of Practical Vertebrate Morphology. J. T. SAUNDERS and S. M. MANTON. 1959. Oxford Univ. Press. London. 272 pp. 55 figs. $7.

A guide to the practical study of those vertebrate animals commonly used in more elementary courses in zoology.

Comparative Endocrinology. Edited by AUBREY GORBSMAN. John Wiley & Sons, Inc., New York. 746 pp. illustrated.

Announced by the publishers as a comprehensive summary of developments through 1958, this is the proceedings of the Columbia University Symposium on Comparative Endocrinology held at Cold Spring Harbor, New York, May 25 to 29, 1958. Most of the 43 chapters (by 45 investigators) treat of endocrine substances in the various classes of vertebrates, but Chapter 18, The Thyroid Hormone in Invertebrates and Lower Vertebrates, is an important exception. Page 304, line 21, should read *Megacyllene robiniae*, not "vobinae."

Fundamentals of Ornithology. JOSSELYN VAN TYNE and ANDREW J. BERGER. 1959. John Wiley & Sons, Inc. New York. 624 pp., illustrated.

This book is designed to provide the background for a graduate course in ornithology but it should also fill other needs such as a quick reference on each of 168 families of birds; a dictionary of terms; a general reference on life history, taxonomy, and anatomy; and a guide to the literature. It treats of such subjects as paleontology (but without figuring Archeopteryx), song, distribution, migration, etc. Each of the 168 families is treated on a separate page with an illustration of a typical number and references to further literature; but there is no key to or other technical diagnosis of the several families; nor do such recently extinct forms as the elephant birds of Madagascar or the moas of New Zealand have a place in this survey of families. A most attractive book.

The Mammals of North America. E. RAYMOND HALL and KEITH R. KELSON. 1959. Ronald Press, New York. 2 vols. 1083 + 79 pp.; (538 of them figs. of skulls); 500 distribution maps; 186 line drawings of living mammals. $35.

This elaborate book consists of technical keys to and description of the families, genera, and 1003 species of mammals inhabiting North America north of and including Panama. The subspecies, some 3679 of them, are not described, but are listed and their distribution described and mapped in terms of the marginal records of each. Occasional habitat and life history notes are included. It is a sumptuous elaborate book worthy of a place in the library of all interested in mammals. The line drawings give an impression far more useful than a photograph to the person interested in technical details. The book opens with an introductory chapter on zoogeography and closes with a chapter on the collecting and preparing of specimens.

Metabolism in the Rumen. E. F. ANNISON and D. LEWIS. 1959. John Wiley & Sons, Inc., New York. 184 pp. $2.75.

Ruminants (cattle, sheep, goats, and other mammals that chew the cud) have the alimentory tract just before the true stomach (abomasium) enlarged into a large sac known as the rumen. Here the bulky fibrous foods on which these animals live are acted upon by enzymes produced by a mixed population of bacteria and symbiotic protozoa. The final products of carbohydrate digestion are delivered to the blood by the wall of the rumen in the form of volatile fatty acids and the more finely divided contents of the rumen are passed on to the stomach and intestine. Protein and non protein nitrogen entering the rumen is largely consumed in the metabolism of the rumen's microbial fauna and flora, the animal deriving its own protein in important measure from dead bacteria and protozoa in the finely commuted materials passed from the rumen. This little book, one of Methuen's Monographs on Biochemical Subjects, deals with the details of these processes.

A Way of Life and Selected Writings. SIR WILLIAM OSLER with an Introduction by G. L. KEYNES. Dover Publications, Inc., New York. 28 pp., illustrated with 2 portraits and other illustrations. $1.50.

Doctor, humanist, teacher of medicine at McGill University, The University of Pennsylvania, Johns Hopkins University, and Oxford University, William Osler (1849–1919) was also curator of the Bodleian Library at Oxford and (after 1911) a baronet of the British Empire. This collection of Osler's essays, originally published in 1951 as "Selected Writings of Sir William Osler" should interest all concerned with the history of the teaching and practice of medicine.

The Biological Sociological and Psychological Aspects of Aging. KURT WOLFF. 1959. Chas. C Thomas, Springfield, Ill. 95 pp.

This book is largely a review of some 120 papers on various aspects of aging. It is concerned mostly with describing the condition and its symptoms, which must, of course, be understood before effective amelioration can be attempted. There is no index. Two quotations are in order:

"Those with simple desires and good dispositions find old age easy to take, and those who do not show wisdom and virtue in their youth are prone to attribute to old age those infirmities which are actually produced by former irregularities." (p. 62, Cicero, whose famous essay is not noted in the bibliography.)

"Persons, who live to be very old, have been able to avoid frustrations and to escape conflicts with authority. They ascribe special value to independence and attempt to apply the principles of democracy as a basis for cooperative and productive living. They worked hard and long hours, but were not anxious to get to the top, and therefore did not suffer from hypertension. They have a social character, a sense of humor and are well liked. They do not worry about things beyond their control, and are disinclined to argue. . . . They are honest with themselves and face sickness and frustrations squarely and objectively without fear, and therefore remain more healthy, and succumb less to acute sickness. They are able to stand catastrophe in their family life and do not react too severely to personal injury." (p. 69, abstracting from F. Dunbar).

CHAPTERS FOUNDED

ALPHA—Ohio State University, Columbus, Ohio, 17 March 1915.

BETA—University of Michigan, Ann Arbor, Michigan, 3 June 1916.

GAMMA—North Dakota Agricultural College, Fargo, North Dakota (1916).

DELTA—University of Maine, Orono, Maine, 27 January 1917.

EPSILON—University of Denver, Denver, Colorado, 5 March 1917.

ZETA—University of Wisconsin, Madison, Wisconsin, 30 May 1917.

ETA—University of Akron, Akron, Ohio, 20 April 1921.

THETA—Michigan State College, Lansing, Michigan, 9 April 1921.

IOTA—Washington University, St. Louis, Missouri, 28 May 1921.

KAPPA—University of Kansas, Lawrence, Kansas, 31 May 1921.

LAMBDA—University of Montana, Missoula, Montana, 4 May 1921.

MU—University of California, Berkeley, California, 27 April 1922.

NU—Washington and Jefferson College, Washington, Pennsylvania, 11 May 1922.

XI—University of Nebraska, Lincoln, Nebraska, 3 May 1924.

OMICRON—University of North Dakota, Grand Forks, North Dakota, 26 May 1924.

PI—Emory University, Georgia, 3 January 1925.

RHO—University of Illinois, Urbana, Illinois, 28 March 1925.

SIGMA—University of Florida, Gainesville, Florida, 4 December 1925.

TAU—Duke University, Durham, North Carolina, 4 March 1926.

UPSILON—Miami University, Oxford, Ohio, 7 May 1926.

PHI—University of New Hampshire, Durham, New Hampshire, 21 May 1926.

CHI—Montana State College, Bozeman, Montana, 11 February 1927.

PSI—University of Washington, Seattle, Washington, 7 April 1928.

OMEGA—University of Oklahoma, Norman, Oklahoma, 24 March 1928.

ALPHA ALPHA—University of Southern California, Los Angeles, California, 17 May 1928.

ALPHA BETA—Mount Union College, Alliance, Ohio, 17 May 1928.

ALPHA GAMMA—University of South Dakota, Vermillion, South Dakota, 15 May 1928.

ALPHA DELTA—Lawrence College, Appleton Wisconsin, 17 March 1929.

ALPHA EPSILON—University of Pittsburgh, Pittsburgh, Pennsylvania, 23 March 1929.

ALPHA ZETA—College of William and Mary, Williamsburg, Virginia, 19 April 1930.

ALPHA ETA—Oklahoma State University, Stillwater, Oklahoma, 13 March 1930.

ALPHA THETA—State College of Washington, Pullman, Washington, May 1930.

ALPHA IOTA—Bucknell University, Lewisburg, Pennsylvania, 9 January 1932.

ALPHA KAPPA—Hunter College, New York City, 8 January 1932.

ALPHA LAMBDA—University of Utah, Salt Lake City, Utah, 13 February 1932.

ALPHA MU—University and State College of Oregon, Eugene-Portland-Corvallis, Oregon, 18 November 1933.

ALPHA NU—University of New Mexico, Albuquerque, New Mexico, 21 April 1935.

ALPHA XI—University of Rhode Island, Kingston, Rhode Island, 17 May 1935.

ALPHA OMICRON—Marquette University, Milwaukee, Wisconsin, 18 June 1938.

ALPHA PI—University of Colorado, Boulder, Colorado, 24 May 1941.

ALPHA RHO—University of Arkansas, Fayetteville, Arkansas, 23 May 1945.

ALPHA SIGMA—University of Texas, Austin, Texas, 2 February 1946.

ALPHA TAU—National University of Mexico, Mexico, D.F., 7 April 1947.

ALPHA UPSILON—University of California at Los Angeles, California, 17 May 1947.

ALPHA PHI—College of Puget Sound, Tacoma, Washington, 28 February 1948.

ALPHA CHI—University of the Philippines, Manila, Luzon, P.I., 12 March 1949.

ALPHA PSI—Virginia Polytechnic Institute, Blacksburg, Virginia, 24 May 1949.

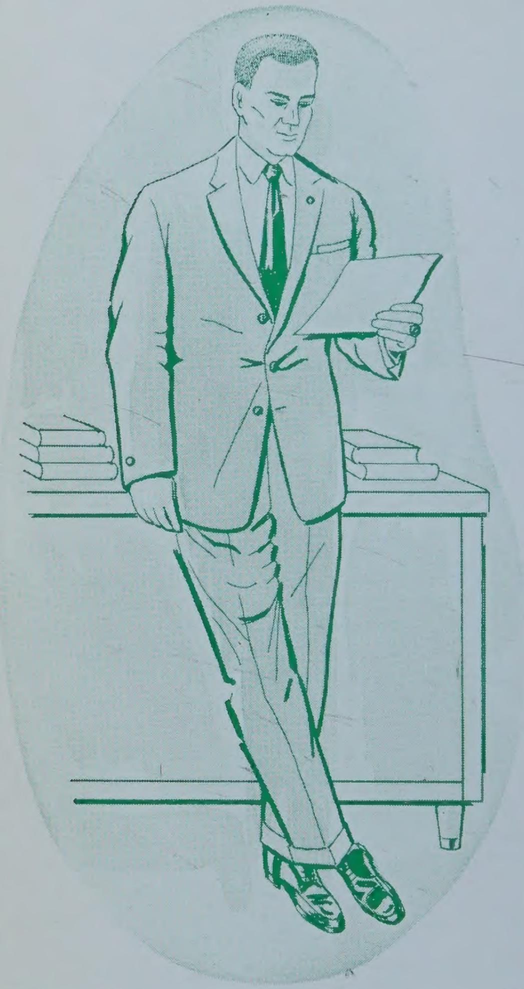
ALPHA OMEGA—University of Georgia, Athens, Georgia, 17 May 1951.

BETA ALPHA—Pennsylvania State Univ., State College, Pennsylvania, 26 May 1955.

BETA BETA—Florida State University, Tallahassee, Florida, 18 February 1956.

BETA GAMMA—Long Island University Brooklyn N. Y., 27 April 1957.

BETA DELTA—University of Virginia Charlottsville, Virginia, 22 March 1958.



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